AUTOMATION OF PRODUCTION

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CONTROL OF DIFFERENTIAL CHARGING OF A GLASSMAKING FURNACE

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An algorithm for controlling differential charging in a glass-making furnace as a function of the category of the charge portions loaded is examined. Charge portions with an elevated content of refractory components are loaded into the furnace zone with high glass-mass temperature, and charge portions with a high content of low-melting components are loaded into the low-temperature zone of the furnace.

The existing algorithms for controlling differential charging in a glassmaking furnace with transverse flame direction largely involve regulating the productivity of charge loaders as a function of the sign and degree of asymmetry of the boundary of the charge and melt foam to the left and right of the longitudinal axis of the loading pocket and changing the charge: ratio when charge quality is predicted to decrease during storage in reserve hoppers [1].

A decrease of charge quality with degradation of the quality of or a change in the category of the loaded portions is neglected in the existing automatic-control algorithms, and data on categories are used only to assess the operation of an individual operating unit and for static analysis of the glass production process.

It is known that the nonuniformity of the charge composition is responsible for up to 60% of rejects in glass production. When a nonuniform batch is used, the sections of the charge which are enriched with low-melting components (soda, sodium sulfate, saltpeter) are predominantly melt first and then the sections enriched with refractory materials (sand and aluminum-containing components) melt.

As a result of fluctuations of the content of low-melting and refractory components in the charge, the position of the boundaries of the charge zone and the melt foam in the tank of the glassmaking furnace changes. When the relative content of sand and aluminum-containing components increase, the extent of the charge zone increases, and when the relative content of soda and other low-melting components of the charge increases, the extent of the foam zone increases [2].

In turn, fluctuations of the extent of the melting zone have a large effect on the temperature uniformity and quality of the glass mass used for production.

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It is virtually impossible to produce a charge with ideal quality; deviations from the prescribed recipe are always present in the charge. These deviations are due to fluctuations of the chemical composition of the raw material and errors in analyzing it, incomplete mixing and errors in dispensing components of the glass charge [3], and local changes of the moisture content, bulk density, and granulometric composition of the raw materials as well as and other destabilizing factors.

The quality of the charge in production is assessed according to five categories depending on the deviations of the mass content of the proportioned materials.

Charge category	Mass content deviations of proportioned components of the charge, %
1	± 0.0 – 0.2
2	± 0.21 – 0.4
3	± 0.41 – 0.6
4	± 0.61 – 0.8
5	± 0.81 – 1.0

When the mass content of a component deviates by more than ± 1.0% from a prescribed value, the charge is removed from the glassmaking process and not further used.

Changes of the category of a glass charge have a large effect on the glass melting process and the thermal uniformity of the glass mass, and they must be taken into account to control the differential charging process in a glassmaking furnace.

This is done as follows in the method proposed for controlling the charging process.

The components of a glass charge which are proportioned in dispensers in the mass line (not shown in Fig. 1) are fed into a mixer *1*, where they are mixed. Depending on the

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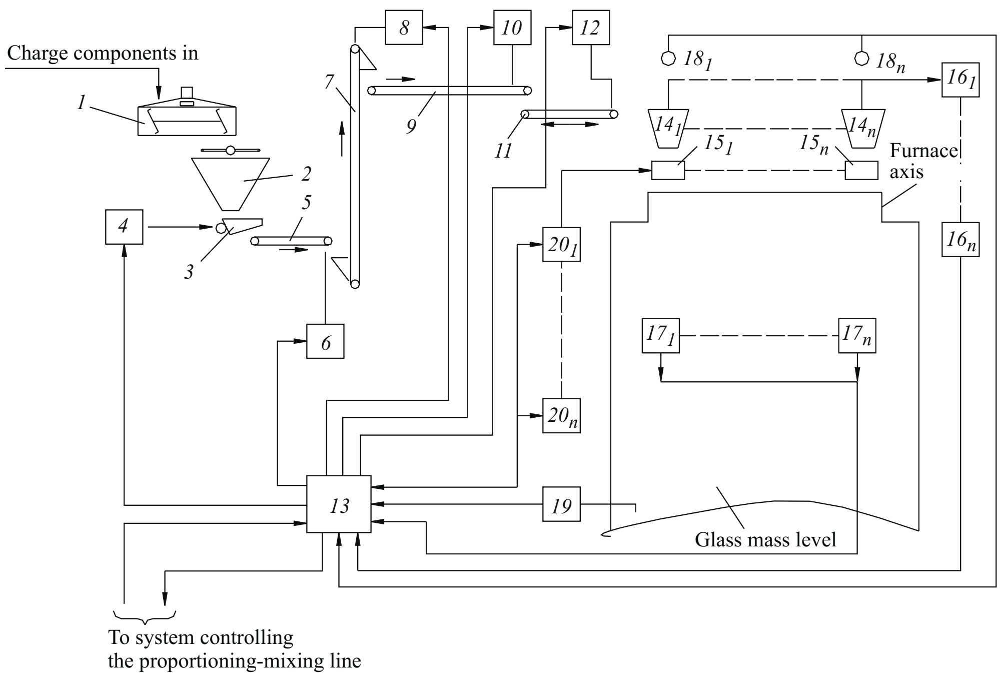

Fig. 1. System controlling differential charging in a glassmaking furnace.

proportioning error of each material (sand, soda, dolomite, chalk, sodium sulfate, saltpeter, feldspar, pegmatite, alumina, and so forth) the system controlling the proportioning-mixing line determines the charge category of the running mix. A lowering of the charge category due to a relative increase of the contents of refractory components can occur when a positive error (increase of content) in the proportioning of refractory components is present and when a negative error (decrease of content) in the proportioning of low-melting components is present. Likewise, a lowering of charge category as result of a relative increase of the content of the low-melting components can occur when a positive error (increase of content) in the proportioning of low-melting components is present and a negative error (decrease of content) in proportioning refractory components is present.

After the time prescribed for mixing the components of the charge has elapsed, a command from the system controlling the proportioning-mixing line opens the unloading slide of the mixer *1* and the ready charge is off-loaded into the dispensing hopper *2*. A vibrational feeder *3*, controlled by the block *4*, feeds the charge from the hopper onto a reversible belt conveyor *5*. If the mixture is rejected (which happens very rarely), the control block *6* reverses the reversible conveyor and the charge is released into the reject line or into a bucket (not shown in Fig. 1). If the proportioning results give a category 1, 2, 3, 4, or 5 charge, then the conveyor *5* (operating in the foreword regime) of the belt elevator *7* (controlled by the block *8*) of the belt conveyor *9* (controlled by the block *10*) feeds the charge into the distributing conveyor *11* (controlled by the block *12*).

A command from the microprocessor block *13* moves the distributing conveyor backward and forward above the hoppers $14_1 - 14_n$ (the maximum number $n = 12$) of the charge loaders $15_1 - 15_n$ and feeds the charge into them in succession. If the loaded portion of charge belongs to category 1, then the charge is distributed uniformly over all hoppers $14_1 - 14_n$ depending on the level to which the hoppers are filled, which the level sensors $16_1 - 16_n$ control.

If the charge portion transported from the mixer 1 to the distributing conveyor 11 belongs to category 2, 3, 4, or 5, then the charge is distributed over the hoppers $14_1 - 14_n$ taking into account, in addition, the distribution of the glass mass temperature over the width of the load pocket.

The temperature field of the glass mass along the width of the load pocket is measured by the temperature sensors $17_1 - 17_5$, the signals from which flow into the microprocessor control block *13*. Ordinarily, the distribution of the glass mass temperature in the load pocket reaches its maximum value along the axis of the glassmaking furnace and its minimum value along the edges on the lateral walls of the load pocket (Fig. 2).

The glass mass temperature in the central zones is the average of the maximum and minimum temperatures. For 12 loading hoppers (600 – 700 tons/day furnace), the hoppers 14_1, 14_2, 14_{11}, and 14_{12} are located opposite the zones of the loading pocket with the minimum glass mass temperature $T_{\min}$, the hoppers $14_3 - 14_5$ and $14_8 - 14_{10}$ are located opposite the loading bucket with the average temperature $T_{\rm av}$, and the hoppers $14_6 - 14_7$ are located at the center of the loading pocket with the maximum glass mass temperature $T_{\max}$.

If the system controlling the proportioning-mixing line feeds into block *13* information about the unloading of category 2 or 3 charge from the mixer as a result of a relative increase of the content of refractory materials in the charge, then the distributing conveyor (controlled by the blocks *12* and *13*) feeds this portion, depending on the fill, into the

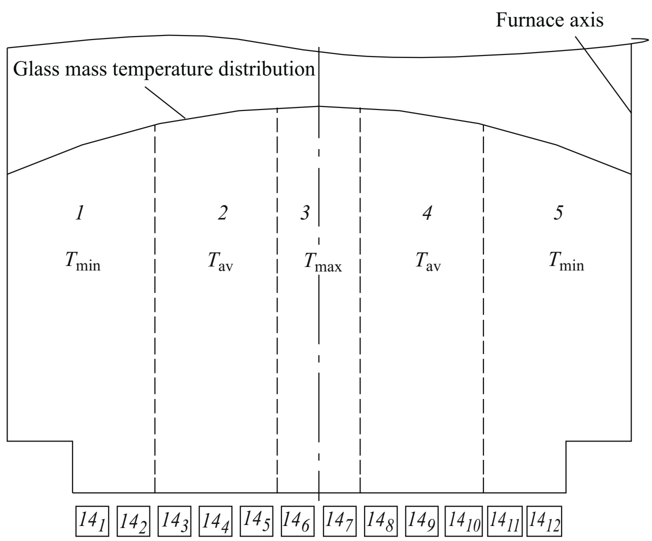

Fig. 2. Charge distribution over the front of the load pocket: *1*) loading zone for category 4 and 5 charge with elevated content of low-melting components; *2*) loading zone of category 2 and 3 charge; *3*) loading zone of category 4 and 5 charge with elevated content of the high-melting components; *4*) loading zone of category 2 and 3 charge; *5*) loading zone of category 4 and 5 charge with elevated content of the low-melting components.

hoppers $14_3 – 14_5$ and $14_8 – 14_{10}$, located to the left and right of the zones of the loading pocket with the average temperature. When portions of category 4 and 5 charge with the maximum relative increase of the content of refractory materials are transported from the mixer *1*, the distributing conveyor *11*, by command from the control block *13*, loads the charge into the hoppers 14_6 and 14_7, lying on the axis of the loading pocket in the zone with the maximum glass mass temperature.

When the category 2 and 3 charge with relative increase of the content of low-melting materials is fed onto the distributing conveyor *11*, depending on the signals from the level sensors $16_3 – 16_5$ and $16_8 – 16_{10}$ the charge is fed into the hoppers $14_3 – 14_5$ and $14_8 – 14_{10}$ located opposite the zones of the loading pocket with the average glass mass temperature.

When category 4 and 5 charge with the maximum relative increase of the content of low-melting materials is fed onto the distributing conveyor *11*, the charge is loaded into the hoppers 14_1, 14_2, 14_{11}, and 14_{12}, located in the zones of the loading pocket with the minimum temperature. The position of the distributing conveyor *11* in all cases where charge is fed into the hoppers $14_1 – 14_n$ is controlled by the corresponding sensors $18_1 – 18_n$.

Charge is fed from the hoppers $14_1 – 14_n$ into the glassmaking furnace depending on the glass mass level. When this level decreases, the signal from the level measuring system *19* enters the control block *13*, which forms commands for switching on the blocks $20_1 – 20_n$ controlling the charge loaders $15_1 – 15_n$. When the glass mass level reaches the normal value, the drives of the charge loaders are switched off.

The control block *13* interacts with the system controlling the proportioning-mixing line along two channels. A signal indicating a decrease of the charge level in the hoppers of the charge loaders $18_1 – 18_n$ enters the system controlling the proportioning-mixing line from the block *13*, and a signal indicating the charge category enters the block *13* from the system controlling the proportioning-mixing line.

In summary, this control method makes it possible to change the distribution of the charge in the load pocket and feed portions of category 2, 3, 4, or 5 charge with high relative content of refractory components into the zone of the loading pocket with a higher temperature and charge portions with higher relative content of low-melting components into the zone of the loading pocket with lower temperature. Differential charging along the front of the loading pocket, take the account of the category of the charge, stabilizes the charge melting process in the glassmaking furnace and increases the thermal uniformity of the glass mass.

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